

**Office of the Secretary Of Defense (OSD)
Director of Defense Research & Engineering
Research Directorate
Small Business Innovation Research (SBIR)
FY2010.3 Program Description**

Introduction

The OSD Director of Defense Research & Engineering (Research Directorate) SBIR Program is sponsoring topics in the Advanced Cooperative and Autonomous Surveillance, Communications and Networking technology theme in this solicitation.

The Air Force is participating in the OSD SBIR Program on this solicitation. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The service laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Innovation Research (SBIR) Program solicitation. In order to participate in the OSD SBIR Program this year, all potential proposers should register on the DoD SBIR Web site as soon as you can, and should follow the instruction for electronic submittal of proposals. It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Web site at <http://www.dodsbir.net/submission>. If you experience problems submitting your proposal, call the help desk (toll free) at 1-866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit of 25 pages. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The DoD SBIR Proposal Submission Web site allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report.

We WILL NOT accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal; there is only a 25-page limit. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the DUSD(S&T) SBIR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the DUSD(S&T) SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Description of the OSD SBIR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the SBIR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to \$100,000. We plan to fund 3 Phase I contracts, on average, and down-select to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals are evaluated using the Phase I evaluation criteria, in accordance with paragraph 4.2 of the DoD Solicitation Preface. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation), with a dollar value up to \$750,000. Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-SBIR funded follow-on contracts for products or processes, which meet the Component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior SBIR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior SBIR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, may be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

- a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
- b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
- c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization.

In addition, the OSD SBIR Program has a Phase II Plus Program, which provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II Plus allows for an existing Phase II OSD SBIR contract to be extended for up to one and a half year per Phase II Plus application, to perform additional research and development. Phase II Plus matching funds will be provided on a one-for-one basis up to a maximum \$500,000 of SBIR funds. All Phase II Plus awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Plus contract modification. The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program must be obligated on the OSD Phase II contract as a modification just prior to or concurrent with the OSD SBIR funds. Private sector funds must be deemed an “outside investor” which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, SBIR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial (both Defense and Private Sector) products. Proposers are encouraged to obtain a contingent commitment for follow-on funding prior to Phase II where it is felt that the research and development has commercialization potential in either a Defense system or the private sector. Proposers who feel that their research and development have the potential to meet Defense system objectives or private sector market needs are encouraged to obtain either non-SBIR DoD follow-on funding or non-federal follow-on funding, for Phase III to pursue commercialization development. The commitment should be obtained during the course of Phase I performance, or early in the Phase II performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify funding to pursue further development for commercial (either Defense related or private sector) purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the topic authors and point of contact identified in the topic description section. Proposals should be electronically submitted. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are prohibited for reasons of competitive fairness; however, to obtain answers to technical questions during the formal Solicitation period, please visit <http://www.dodsbir.net/sitis>. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the SBIR/STTR Interactive Technical Information System (SITIS).

It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Web site at <http://www.dodsbir.net/submission>. (This applies to both Phase I and Phase II proposal submission.) If you experience problems submitting your proposal, call the help desk (toll free) at 866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit of 25 pages. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The proposal submission Web site allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The submission site does not limit the overall file size for each electronic proposal, only the number of pages is limited. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

The following pages contain a summary of the technology focus areas, followed by the topics.

Advanced Cooperative and Autonomous Surveillance, Communications and Networking Technologies for the Tactical Edge

I. Background/Challenge

Due to the changing threat environment, there is a significant increase in the requirements for the internetted persistent surveillance and intelligence, on-the-move connectivity and mobile communications in a multi-dimensional dynamic and disruptive battlespace. At the same time, the capability and capacity to generate increasing amounts of information/data from the numerous sources in the battlespace have increased significantly. The issue of convergence of surveillance data processing and communications has become more challenging. Several S&T efforts (CABLE JCTD, RANGE, WNaN and MAINGATE) to provide information services at the tactical edge are under-way. In spite of these, so far, there is no good viable solution available for high data rate transfer of information securely for Unmanned Aerial Systems at the tactical edge. Currently autonomous capabilities in these areas are emerging globally, but the DoD does not have a focused approach (support and resources) to integrate the most promising technologies and programs and leverage on-going research and development efforts for the current and future missions/warfighters. There are many significant technical challenges for the *identification of anticipated uncertainty* and developing performance trade-offs to have a high level of confidence and assurance in the development and deployment of these advanced cooperative and autonomous new technologies to achieve and maintain dominance.

II. Research Goals/Focus Areas

Research in this technology theme will provide better scientific understanding and technical foundation for developing solutions and performance trade-offs for tackling emerging problems and threats. The following are some selected areas of research: Architecture and Interoperability between and among heterogeneous networks and Gateway functionality to connect and manage together diverse networks; Tagging, Tracking and Locating (TTL) technology; Cooperative Autonomous Robotics and Vehicles; Nanotechnology, small, lightweight steerable antennas, power amplifiers and radios that achieve range and data rates in RF; Optical Switching, All-weather Optical/RF filtering to cope with current and emerging jammer threats.

The Autonomous Networking Technology topics are:

- OSD10-AN1 Cognitive Cross-layer Wireless Networking Architectures and Protocols
- OSD10-AN2 Autonomous Hybrid Tactical Router
- OSD10-AN3 Autonomous Network Management
- OSD10-AN4 Autonomous Routing for Small UAS's
- OSD10-AN5 Wireless Autonomic Airborne Infrastructure

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OSD DDR&E SBIR 10.3 Topic Descriptions

OSD10-AN1

TITLE: Cognitive Cross-layer Wireless Networking Architectures and Protocols

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Design and assess innovative methods to create cognitive cross-layer wireless networking protocols to achieve autonomous network resiliency in contested RF spectra.

DESCRIPTION: Today's wireless network challenges of spectrum efficiency and utilization are becoming an increasingly important factor in the reliable execution of both military and commercial wireless applications. This reality is further exacerbated by the ever-increasing number of users and their competing/conflicting data-rate requirements therein. As such, innovative cross-layer wireless networking protocols are necessary to intelligently adapt communications and networks from the physical layer through the application layer to reliably meet the information system requirements. Ultimately, a new theoretical framework and network architecture based on cognitive processes/reasoners to rigorously derive provably-efficient distributed algorithms for joint adaptive routing and spectrum allocation is needed to achieve network agility and resiliency in contested RF spectra. This revolutionary paradigm poses many new technical challenges in protocol design, size, weight, and power (SWAP), interference metrics, environment awareness, new distributed algorithms, distributed measurements, quality of service (QoS) guarantees, and security. Overcoming these issues becomes even more challenging due to the scarcity of radio resources (e.g., spectrum), the inherent transmission impairments of wireless links (multipath, fading, noise) and user mobility, where the network is comprised of heterogeneous nodes (ground, air, and space assets) and heterogeneous traffic (mixed priority, data rate, and latency requirements).

This topic seeks to develop a cognitive cross-layer protocol framework for wireless networks in which primary users and cognitive radio users can autonomously cooperate for mutual benefit to include: an increase in network capacity, transmission power savings, a reduction in routing latency, and a reduction in over-the-air time by fully taking advantage of the open wireless medium; thus, increasing overall spectrum efficiency and utilization. The fundamental design trade-offs inherent to energy-constrained and band-limited adaptable networks should be considered to efficiently use limited network/radio resources and provide assured, reliable wireless links in harsh, rapidly-changing RF environments by maintaining link stability without sacrificing capacity. Novel means of using spectral information should be designed into the architecture and protocol(s) to control the behavior of network nodes in a distributed fashion and achieve greater network performance and resilience. Decentralized control strategies based on local information/measurements are desired to adaptively reconfigure the physical-layer and routing parameter space if/when links are determined unsuitable for the communications requirements. That is, route selection and spectrum allocation should take into account current spectrum occupancy and user demands/priorities, given network topology dynamicity is governed by the spectrum switching process and asset/node mobility. Solutions that require minimal change to existing waveforms are preferred.

PHASE I: Design candidate solution(s) that provide robust, spectrally-mutable wireless connectivity, operate in highly dynamic environments, and tolerate long feedback delays. Demonstrate, compare, & assess feasibility of the candidate(s) via RF wireless network simulation in terms of scalability and system constraints.

PHASE II: Complete design and development of software-defined-radio prototype systems that implement candidate solutions. Demonstrate within an emulated or experimental airborne network environment. Demo environment should be spectrally dynamic and heterogeneous, hosting multiple MAC layer technologies (e.g. Tactical Targeting Network Technology [TTNT], JTRS Wideband Networking Waveform [WNW], etc., or surrogates) and mobile routing algorithms.

PHASE III / DUAL USE: Military application: Reliable mission-critical time-sensitive info flows amongst in-theater military aircraft and satcom terminals to provide battlespace situational awareness and enable joint tactical edge networking. Commercial application: Solutions can increase network capacity and enhance QoS for commercial mobile wireless and satcom systems. Vendors may commercialize the technology for 802.11 Wi-Fi, 802.16 WiMax, and 802.22 WRAN applications.

REFERENCES:

1. F. Fitzek, M. Katz, "Cognitive Wireless Networks: Concepts, Methodologies and Visions Inspiring the Age of Enlightenment of Wireless Communications," Springer, 2007.
2. J. Mitola, "Cognitive Radio Architecture Evolution," Proceedings of the IEEE, pp. 626–641, April 2009.
3. I. Akyildiz, W. Lee, and K. Chowdhury, "CRAHNS: Cognitive Radio Ad Hoc Networks," Ad Hoc Networks Journal (Elsevier), vol. 7, pp. 810-836, July 2009.
4. L. Ding, T. Melodia, S. Batalama, J. Matyjas, M. Medley, "Cross-layer Routing and Dynamic Spectrum Allocation in Cognitive Radio Ad Hoc Networks," IEEE Trans. on Vehicular Technology, 2010.
5. I. Akyildiz, W. Lee, M. Vuran, S. Mohanty, "Next Generation/Dynamic Spectrum Access/Cognitive Radio Wireless Networks: A Survey," Computer Networks, Volume 50, Issue 13, 15 September 2006, Pages 2127-2159.
6. M. Chiang, S. Low, A. Calderbank, and J. Doyle, "Layering as Optimization Decomposition: A Mathematical Theory of Network Architectures," Proceedings of the IEEE, vol. 95, pp. 255–312, Jan. 2007.
7. R. Thomas, D. Friend, L. DaSilva, A. Mackenzie, "Adaptation and Learning to Achieve End-to-End Performance Objectives," IEEE Communications Magazine, December 2006.

KEYWORDS: Cognitive Networks, Cross-layer Design, Dynamic Spectrum Access, Agile Communications, Software-defined Radio

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OSD10-AN2 **TITLE:** Autonomous Hybrid Tactical Router

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective is to develop and demonstrate autonomous network integration of emerging Tactical Targeting Network Technology (TTNT), mini CDL, WiMax, Free Space Optical and existing Joint Capability for Airborne Networking (JCAN) subnets and links to enhance Tactical Routing.

DESCRIPTION: Emerging tactical networks for ISR, C2 and Targeting do not provide end to end connectivity (sensors to shooters). Current ISR, C2 and Targeting networks provides mission specific implementations, networks operate on different frequencies, use different waveforms, provide limited autonomous switching and routing capability. To enable networked information exchange among C2, ISR, and Tactical targeting networks (machine to machine) autonomous end to end networking must be developed. The intent is to provide heterogeneous net integration (dynamic subnet link and route assignment, dynamic IP subnet address allocation, dynamic subnet domain name services)

PHASE I: Design hybrid routing technical approach to provide networking between Free Space Optical, TTNT, WiMax, CDL and JCAN sub networks. The hybrid router design should leverage commercial router practices that provide a common switching fabric while interchanging line cards operating at different data rates (i.e.. T1, DS-3, OC-192).

PHASE II: Develop and demonstrate prototype hybrid router of design developed in phase I. Characterize static link and network performance, bit error rate, packet loss. Develop, demonstrate and analyze link fade, optical polarization rotation, pointing and tracking, antenna gain, link margins, bit error rates. Develop, demonstrate and analyze multi link, multi channel, multi-antenna multipath routing and communications topology. Develop and

demonstrate static routing (mesh, ring, hub and spoke) between multiple subnets. Develop and demonstrate mobile ad hoc routing between multiple subnets node join/leave, net join/leave.

REFERENCES:

1. Joint Capability for Airborne Networking (JCAN)
2. Optical RF Communications Adjunct (ORCA)
3. Battlefield Airborne Communications Node (BACN)

KEYWORDS: heterogeneous networking, hybrid routers, RF and Optical Communications

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OSD10-AN3 TITLE: Autonomous Network Management

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide a technology that automatically determines network status/condition and takes appropriate corrective actions as necessary.

DESCRIPTION: A modular architecture that ingests available IP network status information, reasons what this information means about the condition of the network, determines if corrective action is necessary, and initiates appropriate corrective actions as necessary.

The Department of Defense has a limited number of network operators to examine network status data, which can be both voluminous and dynamic, particularly in tactical networks, and configure/re-configure the large number of network devices present in any theater of operation. The need to maintain network operation to avoid loss of time sensitive mission data, and when necessary reconstitute network operation as quickly as possible to minimize time sensitive mission data loss, drives the need to maximize automation. Automation is needed in every phase of the process: from data collection, to data analysis, to re-planning, to configuration. Furthermore, the unreliability and low-bandwidth link conditions common in tactical network environments present additional challenges. Bandwidth limitations mean that network operations must be maintained with a minimum of overhead by being selective about data transmitted over the air, transmitting that data efficiently, limiting distribution of the data, etc. Unreliable wireless links mean that network management functions must survive in the face of intermittent connectivity, which drive us toward approaches that reduce reliance on a central management entity and increase autonomy.

Potential technologies for this topic include, but are not limited to: policy-based network management, distributed agents, expert systems, data mining, data compression, semantic reasoning, network management protocols, flow-based end-to-end traffic measurement, process automation protocols, disruption tolerant network protocols. More than likely, the target solution may involve more than one of these technologies.

Challenges for this topic include 1) developing methods for efficiently collecting and distributing network status or network status related data from sources such as local devices, peer nodes, applications, planning systems, navigation systems, etc., 2) interpreting static data elements, trends, relationships to other data elements, etc., 3) producing recommended courses of action, and 4) facilitating rapid implementation of courses of action.

The focus of this effort is two fold and involves the development of algorithms leading to the automation of network management processes (e.g. data collection, analysis, course of action determination), and a modular architecture for the system implementing the algorithms. A modular architecture would enable the system to be rapidly upgraded to incorporate new data sources, interface to other network management systems, etc.

The OSD is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are encouraged.

PHASE I: Complete a feasibility study and research plan that establishes the proof of principle of the approach for a modular architecture to increase network management automation/autonomy. Identify the critical technology issues that must be overcome to achieve success. Prepare a revised research plan for Phase 2 that addresses critical issues.

PHASE II: Produce a prototype system that is capable of representing some degree of automation/autonomy across the spectrum of network management functions from data collection through re-configuration. The prototype should lead to a demonstration of the capability. Test the prototype in a real or simulated network representative of a tactical environment with at least two different network management scenario threads.

PHASE III: Produce a system capable of deployment in an operational setting of interest. Test the system in an operational setting in a stand-alone mode or as a component of larger system. The work should focus on capability required to achieve transition to program of record of one or more of the military Services. The system should provide metrics for performance assessment.

REFERENCES:

1. Ritu Chadha, Latha Kant, "Policy-driven Mobile Ad-Hoc Network Management," John Wiley & Sons, 2008
2. Mark A. Miller, P.E., "Managing Internetworks with SNMP Third Edition," M&T Books, 1999.
3. Ralph A. Preston, "Autonomous Network Management,"
http://www.mitre.org/news/events/tech03/briefings/communication_network/preston.pdf
4. Ramy Farha and Alberto Leon-Garcia, "Blueprint for an Autonomic Service Architecture," International Conference on Autonomic and Autonomous Systems, 2006
5. Chonho Lee and J. Suzuki, "Biologically-Inspired Design of Autonomous and Adaptive Grid Services," International Conference on Autonomic and Autonomous Systems, 2006

KEYWORDS: network management, mobile networks, tactical networks, network management protocols, autonomous network management

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OSD10-AN4 TITLE: Autonomous Routing for Small UAS's

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Provide technology to enable autonomous routing for information exchange in the small unmanned aerial systems (SUAS) environment, including SUAS, ground nodes, as well as reachback capabilities.

DESCRIPTION: The SUAS environment is subject to severe constraints, and poses an extremely difficult environment in which to implement data communications. This highly dynamic environment consists of platforms often limited in payload capability, as well as available power. Flight characteristics generally provide a highly

dynamic communications environment, drastically affected by aircraft movement, and flight characteristics. Available communications link capabilities, when used in this environment, suffer from higher error rates, and typically lower data rates, and spotty availability. All of these factors contribute to a scenario requiring highly dynamic, lightweight, scalable, robust and adaptive routing capabilities.

Specific challenge areas for the topic include: 1) Small size, weight and power (SWAP), with the associated limits in bandwidth and range. Although not exclusively, of interest is 1) Technology to provide communications and routing for very small (Ounces) platforms. 2) Highly dynamic link conditions caused by limited power, airframe flight dynamics, environment and jamming. This includes routing for an environment that is disrupted, and not always connected via reachback to the "GIG". 3) Lack of a specific configuration, with platforms and connectivity being "opportunistic". An example would be a random overflight of an SUAS platform, providing short, but useful connectivity for deployed users. 4) Scalability – Many of the protocols and techniques for routing in this environment lack the ability to scale to larger numbers of nodes, requiring use of large percentages of available bandwidth for routing, or requiring architectural adaptations.

The focus of this effort is to develop novel routing approaches to this challenging networking environment. As with any networking system, no one layer can solve all the issues at hand. As such, it is appropriate to look at total system solutions, or cross layer designs, to provide technology solutions to the problem. The effort should develop implementable, and deployable concepts and solutions. The OSD is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are encouraged.

PHASE I: Demonstrate concept feasibility of a technical approach to develop novel and unique routing capability(s) for the SUAS environment. Research should focus on one or more of the key areas identified in the Description above: 1) Micro size platforms, 2) Highly dynamic environments, 3) Opportunistic, random communications, and 4) Scalability. Identify key capabilities and challenges of the proposed technology solution, addressing challenges of the SUAS environment. Provide background including any appropriate supporting information (e.g. modeling and simulation results, supporting test data, etc)

PHASE II: Develop a prototype capability outlined and proposed in phase I. Develop and perform a demonstration of the capability. The demonstration should consist of an adequate number of nodes or simulated nodes to demonstrate the concepts and performance of the routing technology developed, as well as appropriate applications and data traffic flow generation. The demonstration should be based on a relevant operational scenario, which the government will assist in developing.

PHASE III: Produce a system capable of larger scale, deployed testing and demonstration of developed routing capabilities, including potential integration into SUAS airframes for flight testing. Work should provide metrics for performance testing of the technology, as well as assessing the operational utility of the technology. Support the capability required to transition the effort results into operational system or programs of record.

REFERENCES:

1. A Full Scale Wireless Ad Hoc Network Test Bed <http://ecee.colorado.edu/~timxb/timxb/pubs/05isart.pdf>
2. Connectivity Augmentation in Tactical Mobile Ad hoc Networks
<http://www.usukita.org/papers/4088/additionalNodes.pdf>
3. Design and Implementation of a Self-configuring Ad-hoc Network for Unmanned Aerial Systems
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.140.1372&rep=rep1&type=pdf>
4. CONNECTING THE EDGE: Mobile Ad-Hoc Networks (MANETs) for Network Centric Warfare
www.au.af.mil/au/awc/awcgate/cst/bh_peacock.pdf
5. Self-configuring ad-hoc networks for unmanned aerial systems
https://smartech.gatech.edu/bitstream/1853/22626/1/christmann_hans_claus_200805_mast.pdf

KEYWORDS: routing protocol, Mobile Ad-Hoc network, Small UAS, tactical edge networks

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OSD10-AN5 TITLE: Wireless Autonomic Airborne Infrastructure

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide an autonomic wireless networking infrastructure that offers near-commercial grade throughput to edge data producers/consumers using thousands of airborne network nodes.

DESCRIPTION: A predominantly/entirely unmanned airborne networking fabric that autonomously reconfigures and redeploys in accordance with edge user demands for information push and pull.

The DoD is rapidly increasing the number of unmanned platforms it is purchasing and the ability to persist these platforms for long periods of time is also increasing. At the same time, DoD is pursuing concepts in airborne networking for both manned and unmanned platforms.

Assumption 1: There is a tendency to assume that these platforms have a primary mission as a sensor platform which uses an embedded communication link of some nature to offload the data collected.

Assumption 2: The airborne networking concepts have assumed a relatively sparsely connected fabric and because of this sparseness, each platform must have increased transmission power to overcome the distances involved.

Assumption 3: Finally, traditional edge user solutions in DoD tend to assume that there is but one mode of data communication for that user (e.g. tactical satellite communications) to push/pull information from their location – a one-to-one relationship.

This topic intends to challenge these assumptions by postulating a network comprised of thousands of long persistence platforms (whose primary role is that of communications) that provide end to end connectivity via a series of short, low power hops. From the edge user perspective, there are many ‘wireless access points’ available for use. Where the commercial world would connect that user with a single wireless access point, this topic looks to allow that users traffic to be split among all potential information carriers. Each node on the network has a one-to-many relationship with other receivers of its transmitted information.

Challenges for this topic include 1) architecture development and optimization through innovative use of spectral and spatial diversity, 2) optimal combinations of omnidirectional and/or directional antennas to maintain the network and information distribution, 3) tradeoffs in frequency usage, antenna size, size/weight/power (usage) considerations, transmission power requirements, etc., 4) small, lightweight electronically steerable antennas, 5) combined RF/optical systems, 6) network management, 7) omni/directional MANET media access control and routing techniques, 8) autonomic reconfiguration based on demand.

PHASE I: Complete a feasibility study through the use of modeling and simulation (e.g. OPNET) assessing architectural tradeoffs and identifying primary areas for phase two investigation and prototyping which will make greatest progress toward the goals outlined above

PHASE II: Based on the technical areas listed above, and the results of the Phase 1 investigation, produce a prototype (where possible) that can be used for future demonstration. In those cases where prototyping is not possible (e.g. demonstration of a several thousand node architecture) it is expected that enhanced and refined analysis will be performed based on the M&S environment accomplished in Phase 1.

PHASE III: Produce components or systems that can be evaluated in a live-fly environment. Test the system in an operational setting in a stand-alone mode or as a component of a larger system. If components are M&S based, deliver modular components that can be used in future M&S analysis of similar architectures or reused in other modeling activities.

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KEYWORDS: Autonomic MANET, Directional antenna ad hoc networks, wireless mesh networks, airborne networking

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